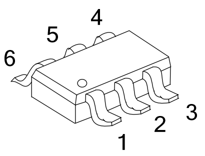
UD05307

CMOS IC

5V, 3A, 1MHz SYNCHRONOUS STEP-DOWN CONVERTER



SOT-26

■ DESCRIPTION

The UTC **UD05307** is a constant frequency, current mode, step-down converter. It can achieve up to 3A continuous output current from 2.5V to 5.5V input voltage with excellent load and line regulation. The output voltage can be regulated as low as 0.6V.

The device also can run at 100% duty cycle for low dropout operation.

The device features cycle-by-cycle current limit protection which prevents the device from the catastrophic damage in output short circuit, over current or inductor saturation. An internal soft-start function prevents inrush current during start-up.

The device also includes Input Under-voltage lockout, Input over-voltage protection, Output under-voltage protection, Output Over-voltage protection and Over-temperature protection to provide safe and smooth operation in all operating conditions.

■ FEATURES

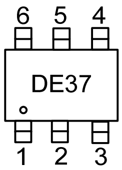
* 2.5V to 5.5V Input Voltage Range
* 3A Available Load Current
* 1MHz Constant Switching Frequency
* Low R_{DSON} for Internal Switches:
  High-side: 65mΩ
  Low-side: 45mΩ
* 65μA Typical Quiescent Current
* Soft Start Time: 1ms
* Peak Current Mode Control
* 100% Duty Cycle in Dropout
* Input Under-Voltage Lockout
* Input Over-Voltage Protection
* Output Under-Voltage Protection
* Output Over-Voltage Protection
* Power Good Output Function
* Output Auto Discharge Function
* Cycle-by-cycle Over Current Limit
* Short Circuit with Hiccup Mode
* Over-Temperature Protection

■ ORDERING INFORMATION

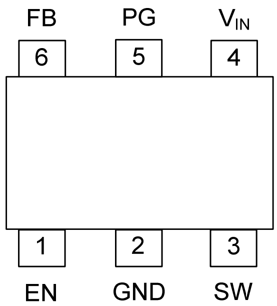
Ordering Number		Package	Packing
Lead Free	Halogen Free		
UD05307L-AG6-R	UD05307G-AG6-R	SOT-26	Tape Reel

UD05307G-AG6-R (1)Packing Type (2)Package Type (3)Green Package	(1) R: Tape Reel (2) AG6: SOT-26 (3) G: Halogen Free and Lead Free, L: Lead Free

■ MARKING



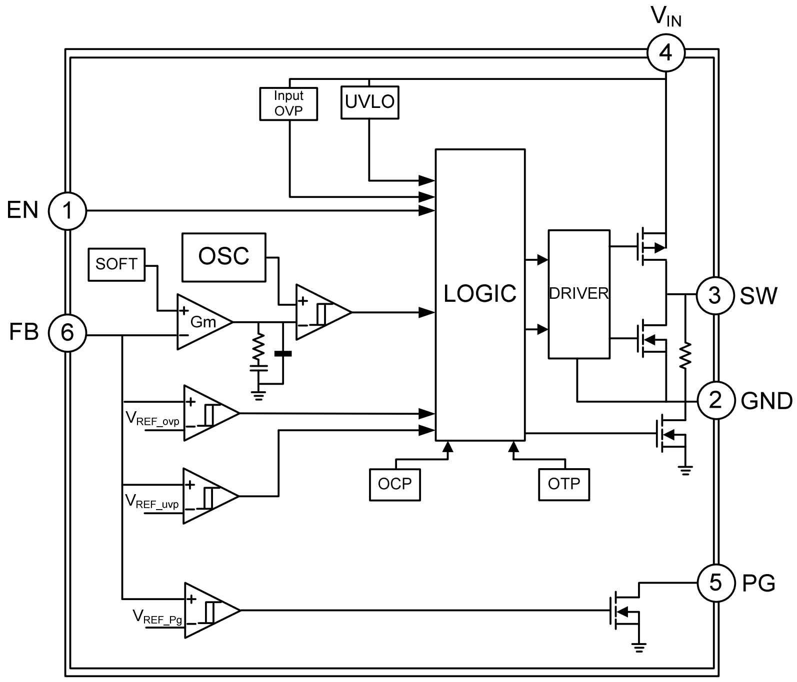
■ PIN CONFIGURATION



■ PIN DESCRIPTION

PIN NO.	PIN NAME	DESCRIPTION
1	EN	Chip Enable Pin. Forcing this pin above 1.5V enables the device. Forcing this pin below 0.4V shuts down the device.
2	GND	Ground Pin
3	SW	Switch node connection to inductor. This pin connects to the drains of the internal main and synchronous power MOSFET switches
4	V_{IN}	Supply Voltage Pin
5	PG	Open-drain power-good indicator output
6	FB	Output Voltage Feedback Pin

■ BLOCK DIAGRAM



■ ABSOLUTE MAXIMUM RATING (NOTE 1) (T_A=25°C, unless otherwise specified)

PARAMETER	SYMBOL	RATINGS	UNIT
Input Supply Voltage	V_{IN}	-0.3 ~ 6.5	V
SW Voltage	$V_{SW, DC}$	-0.3 ~ 6.5	V
SW Voltage (Less than 40ns)	$V_{SW, AC}$	-3 ~ 7	V
EN, FB Voltages	V_{EN}, V_{FB}	-0.3 ~ 6.5	V
PG Voltage	V_{PG}	-0.3 ~ 6.5	V
Operating Junction Temperature	T_J	-40 ~ +160	°C
Storage Temperature	T_{STG}	-65 ~ +150	°C

Note: Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only, functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute maximum-rated conditions for extended periods may affect device reliability.

■ RECOMMENDED OPERATING CONDITIONS

PARAMETER	SYMBOL	RATINGS	UNIT
Supply Input Voltage	V_{IN}	2.5 ~ 5.5	V
Ambient Temperature Range	T_A	-40 ~ +85	°C
Operation Junction Temperature Range	T_J (Note 2)	-40 ~ +125	°C

Notes: 1. The device is not guaranteed to function outside its operating conditions.

2. T_J is calculated from the ambient temperature T_A and power dissipation P_D according to the following formula: $T_J = T_A + P_D \times \theta_{JA}$.

■ THERMAL DATA

PARAMETER	SYMBOL	RATINGS	UNIT
Junction to Ambient	θ_{JA}	100	°C/W

■ ELECTRICAL CHARACTERISTICS (V_{IN}=5V, V_{OUT}=1.8V, T_A=25°C, unless otherwise specified)

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
GENERAL SECTION						
Input Voltage Range	V_{IN}		2.5		5.5	V
Quiescent Current	I_Q	V_{FB} = 105%×V_{FB}, SW open		65	95	µA
Shutdown Current	I_{SD}	V_{EN} = 0V		0.1	1	µA
CONTROL SECTION						
Wake Up V_{IN} Voltage	V_{UVLO}	V_{IN} Rising	2.32	2.4	2.48	V
Input UVLO Hysteresis	V_{UVLO_Hy}			150		mV
Input Over-Voltage Protection Threshold	V_{IN_OVP}		5.7	6.0	6.3	V
Input Over-Voltage Protection Hysteresis	$V_{IN\_OVP\_Hy}$			250		mV
EN High-Level Input Voltage	V_{ENH}		1.5			V
EN Low-Level Input Voltage	V_{ENL}				0.4	V
Turn On Delay Time	T_{ON_Delay}			500		µs
Soft Start Time	T_{SS}	V_{OUT} from 0 to 100%		1		ms
MODULATOR SECTION						
Regulated Feedback Voltage	V_{FB}		0.588	0.600	0.612	V
Switching Frequency	F_{SW}	CCM Mode	0.65	1	1.35	kHz
High-Side Switch Resistance	R_{DSON_H}	I_{SW} = 100mA		65		mΩ
Low-Side Switch Resistance	R_{DSON_L}	I_{SW} = -100mA		40		mΩ
SW Node Discharge Resistance	R_{DIS}			100		Ω
ON-TIME TIMER CONTROL						
Minimum Turn-On Time	T_{ON_MIN}			50		ns
POWER GOOD						
PG Under-Voltage Recovery Threshold (PG From Low to High)	$V_{PG\_UV\_H}$		85	90	95	V_{FB}%
PG Under-Voltage Threshold (PG From Low to High)	$V_{PG\_UV\_L}$		80	85	90	V_{FB}%
PG Over-Voltage Threshold (PG From Low to High)	$V_{PG\_OV\_H}$		110	115	120	V_{FB}%
PG Over-Voltage Recovery Threshold (PG From Low to High)	$V_{PG\_OV\_L}$		105	110	115	V_{FB}%
PG Pin Leakage Current	I_{PG_Leak}		0		1	µA
PG Pin Sink Current	I_{PG_Sink}	V_{PG}=0.5V	1	1.5	2	mA
PROTECTION SECTION						
Output Under-Voltage Protection Threshold	V_{UVP}			66		V_{FB}%
Output Over-Voltage Protection Threshold	V_{OVP}			115		V_{FB}%
Output Over-Voltage Protection Hysteresis	V_{OVP_Hy}			7		V_{FB}%
Hiccup ON-Time	T_{HICCUP_ON}			2.5		ms
Hiccup OFF-Time	T_{HICCUP_OFF}			14.5		ms
High-Side Switch Peak Current Limit	I_{LIM_H}			4.5		A
Over-Temperature Protection Threshold	OTP			160		°C
Over-Temperature Protection Hysteresis	OTP_{Hy}			20		°C

OPERATION DESCRIPTION

Overview

The **UD05307** is a high performance 3A monolithic step-down converter. The device operates at typically 1MHz frequency pulse width modulation (PWM) at moderate to heavy load currents. The **UD05307** requires only three external power components (C_{IN}, C_{OUT} and L). The internal error amplifier and compensation provides excellent transient response, load regulation, and line regulation. Soft start function avoids excessive inrush current and creates a smooth output voltage rise slope. The device adopts the peak current control by sensing the current of the high-side switch, The switch current limit prevents the device from high inductor current and drawing excessive current from input voltage.

Power Saving Mode

The **UD05307** automatically enters power saving mode(PSM) at light load to maintain high efficiency. As the load current decreases and eventually the inductor current ripple valley touches the zero current, which is the boundary between continuous conduction and discontinuous conduction modes. The low-side switch is turned off when the zero inductor current is detected. As the load current is further decreased, it takes longer time to discharge the output capacitor to the level that requires the next on-time. The switching frequency decreases and is proportional to the load current to maintain high efficiency at light load.

Maximum Duty Cycle Operation

The **UD05307** is designed to operate in dropout at the high duty cycle approaching 100%. The **UD05307** implements skip off-time function to achieve high duty approaching 100%. Therefore, the maximum output voltage is near the minimum input supply voltage of the application for input voltage momentarily falls down to the normal output voltage requirement. The input voltage at which the devices enter dropout changes depending on the input voltage, output voltage, switching frequency, load current, and the efficiency of the design.

EN Enable

The EN pin is provided to control the device turn-on and turn-off. When the EN pin voltage is above the V_{ENH} threshold (1.5V), the device is enabled. When the EN pin voltage falls below the V_{ENL} threshold (0.4V), the **UD05307** is disabled and enters shutdown mode.

Soft Start

The **UD05307** has a built-in soft start circuit that can control the rate of output voltage rise, avoiding excessive surge currents during IC startup. The typical soft start time from 0% V_{OUT} to 100% V_{OUT} is usually 1ms.

Input Under-Voltage Lockout

Input under-voltage lockout (UVLO) monitors the input voltage. When the input voltage is higher than the V_{UVLOH} threshold voltage (typ.2.4V), the device turns on. Once the input voltage drops below the threshold with hysteresis (typ.0.15V), the device will shut down.

Input Over-Voltage Protection

Input over-voltage protection (OVP) monitors the input voltage. When the input voltage is above the OVP threshold voltage(typ.6.0V), the device shuts down. Once the input voltage drops below the threshold with hysteresis (typ.0.25V), the **UD05307** will return to normal operation automatically.

Output Under-Voltage Protection

The **UD05307** detects output under-voltage by monitoring the feedback voltage on the FB pin. When the feedback voltage is below 66%V_{FB}, the IC enters hiccup mode to periodically disable and restart the switch operation.

Output Under-Voltage Protection

The **UD05307** includes an output over-voltage protection (OUTOVP) circuit to limit output voltage and minimize output voltage overshoot. If the V_{FB} goes above the 115% of the reference voltage, the high-side MOSFET will be forced off to limit the output voltage, When the V_{FB} drops to 108% of the reference voltage, the control of the high-side MOSFET will be released.

■ OPERATION DESCRIPTION (Cont.)

Over-Current Limit Protection and Output Short Protection

The **UD05307** has cycle-by-cycle peak current limit function. When the inductor current peak value is larger than the peak current limit during high side MOSFET on state, the device enters into peak over current protection mode and low side MOSFET keeps on state until inductor current drops down to the value equal or lower than the peak current limit, and then on time pulse could be generated and high side MOSFET could turn on again. If the output is short to GND and the output voltage drop until feedback voltage V_{FB} is below the output under-voltage threshold which is typically 66% of reference voltage, The **UD05307** enters into hiccup mode to periodically disable and restart switching operation. The hiccup mode helps to reduce power dissipation and thermal rise during output short condition. The period of **UD05307** hiccup mode is typically 17ms.

Power Good Indication

The **UD05307** features an open-drain power-good output (PG) to monitor the output voltage status. The output delay of comparator prevents false flag operation for short excursions in the output voltage, such as during line and load transients. Pull up PG with a resistor to V_{IN} or an external voltage below 5.5V. When V_{IN} voltage rises above V_{UVLO}, the power-good function is activated. PG is high when V_{FB} is between 90% and 115% of normal during the ascent, and PG is high when V_{FB} is between 110% and 85% during the descent. The rest are low.

Output Active Discharger

When the **UD05307** is disabled by EN pin, input UVLO or OTP, the device discharges the output capacitors (via SW pin) through an internal discharge resistor 100Ω connected to ground. This function prevents the reverse current flow from the output capacitors to the input capacitors once the input voltage collapses. It doesn't need to rely on another active discharge circuit for discharging output capacitors. This function will be turned off when the fault condition is removed.

Over -Temperature Protection

The **UD05307** includes over-temperature Protection function. When the junction temperature exceeds about 160°C, the OTP will turn off the switch operation. Once the junction temperature drops to about 140°C, the IC will resume normal operation.

Input Capacitor Selection

The input capacitor C_{IN} is needed to filter the fluctuations caused by the pulsating current at the source of the high-side power MOSFET. A 22μF ceramic capacitor for most applications is sufficient. A large value may be used for improved input voltage filtering. Ceramic capacitors with X5R or a better grade ceramic capacitor dielectrics are highly recommended because of their low ESR and small temperature coefficients.

A 0.1μF ceramic capacitor should be placed close to the V_{IN} pin and GND pin for bypassing. In applications, place the input capacitor CIN as close as possible to the V_{IN} and GND pins of the IC. It is recommended to place the C_{IN} within 1cm of the IC.

Output Capacitor Selection

The output voltage ripple at the switching frequency is a function of the inductor current ripple going through the output capacitor's impedance. The output peak-to-peak ripple voltage ΔV_{OUT}, caused by the inductor current ripple, is composed of ESR ripple ΔV_{ESR} and capacitor ripple ΔV_{Cap}. The functional relationship of the output ripple is expressed by Equation (1):

$$\Delta V_{OUT} = \Delta V_{ESR} \times \Delta V_{Cap} = \Delta I_L \times R_{ESR} + \frac{\Delta I_L}{8 \times C_{OUT} \times F_{SW}} \quad (1)$$

Where R_{ESR} is equivalent impedance on capacitor.

Two 22μF ceramic capacitors can satisfy most applications

■ APPLICATION INFORMATION

Output Voltage Setting

Figure 1 shows the output voltage setting circuit of the **UD05307**. The external resistance voltage divider can set the output voltage according to equation (2).

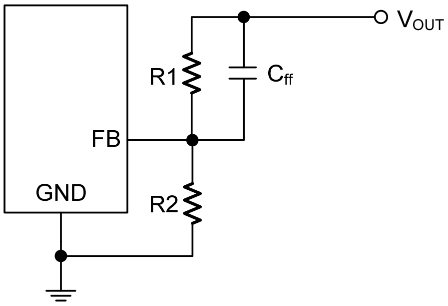


Figure. 1 Output Voltage Setting Circuits

$$V_{OUT}=V_{FB}\times(1+\frac{R1}{R2})=0.6V\times(1+\frac{R1}{R2}) \quad (2)$$

Current consumption and noise sensitivity need to be considered in the selection of resistance R2. A feed forward capacitor Cff improves the loop bandwidth to make a fast transient response, but using a larger Cff brings stability problems.

Inductor Selection

Inductance value, switching frequency, input voltage and output voltage together determine the ripple of inductance current and then affect the output ripple. The ripple of the inductor current can be obtained by Equation (3).

$$\Delta I_L=V_{OUT}\frac{1-\frac{V_{OUT}}{V_{IN}}}{L\times F_{SW}} \quad (3)$$

Where ΔIL is the inductor current ripple, F_{SW} is the switching frequency.

To calculate the maximum inductor current under static load conditions, Equation (4) is given:

$$I_{L,\,MAX}=I_{OUT,\,MAX}+\frac{\Delta I_L}{2} \quad (4)$$

Table 1. Recommended Components Selection

V_{OUT} (V)	R1 (kΩ)	R2 (kΩ)	Cff (pF)	L (μH)	C_{OUT} (μF)
3.3	100	22.1	22	2.2	44-88
1.8	100	49.9	22	2.2	44-88
1.5	100	66.5	22	2.2	44-88
1.2	100	100	100	2.2	44-88
1.05	100	133	100	2.2	44-88
1.0	100	150	100	1	44-88
0.9	100	200	100	1	44-88

■ TYPICAL APPLICATION CIRCUIT

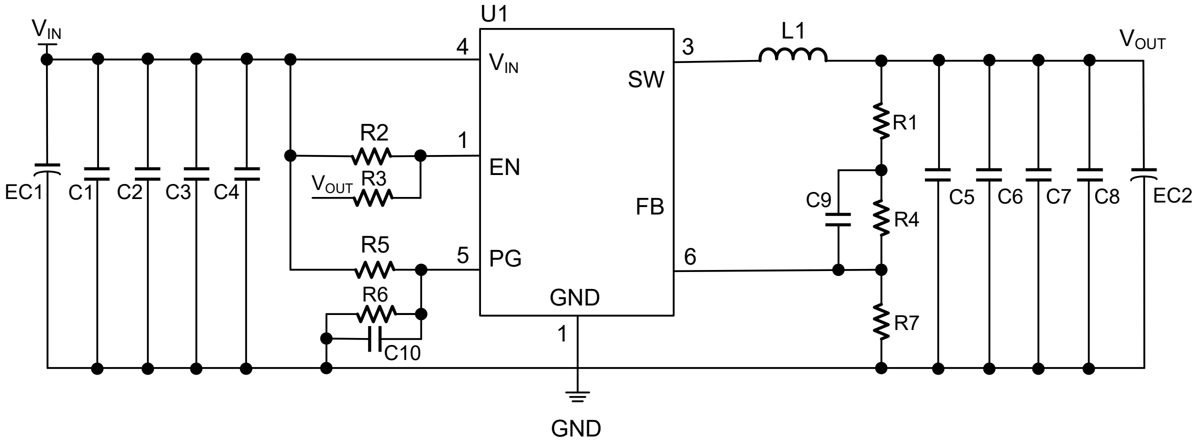
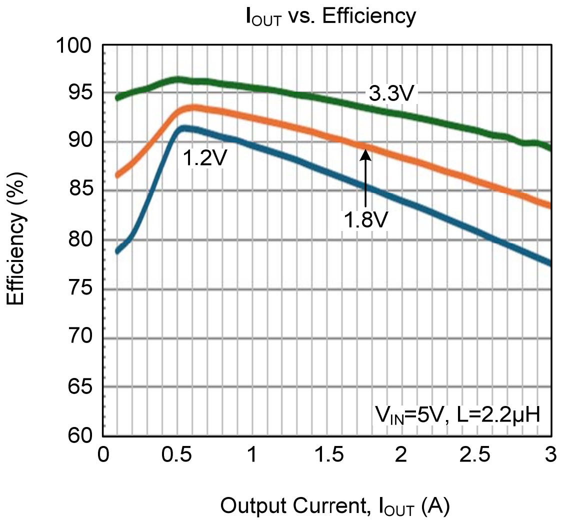
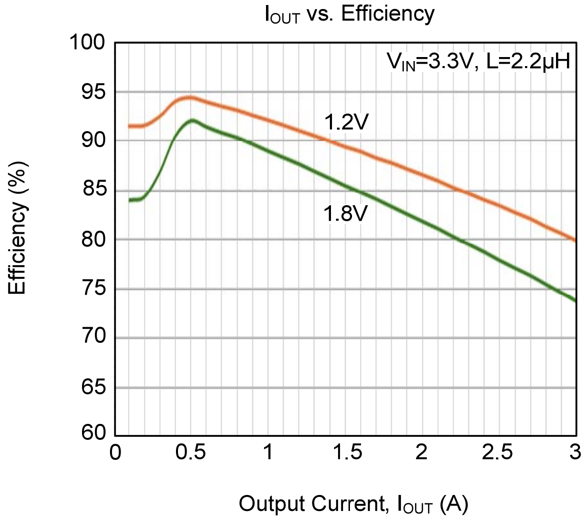


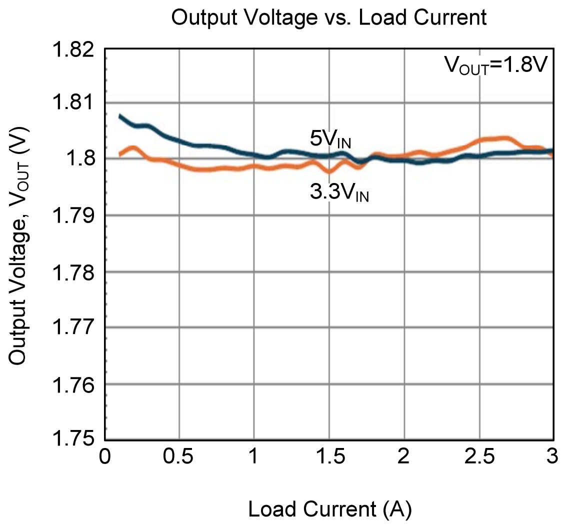
Table 2. Recommended Component Values

Qty	Ref	Value	
1	C3	22μF	
1	C4	0.1μF	
2	C5,C6	22μF	
1	C9	V_{OUT}=3.3V	22pF
		V_{OUT}=1V	100pF
0	C1,C2, C7,C8,C10	NC	
0	EC1,EC2	NC	
1	R1	0Ω	
1	R2,R4,R5	100kΩ	
0	R3,R6	NC	
1	R7	V_{OUT}=3.3V	22.1kΩ
		V_{OUT}=1V	150kΩ
1	L1	V_{OUT}=3.3V	2.2μH
		V_{OUT}=1V	1μH
1	U1	/	

■ TYPICAL CHARACTERISTICS

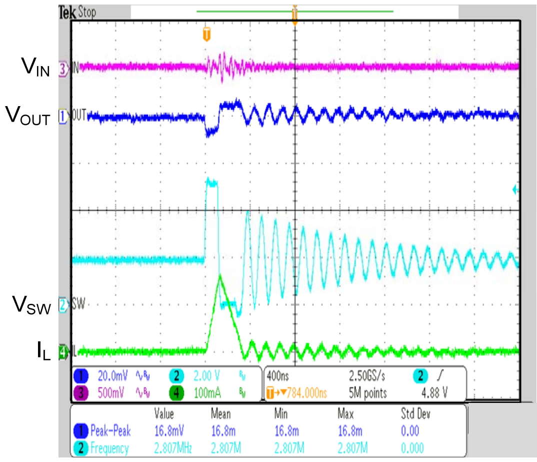




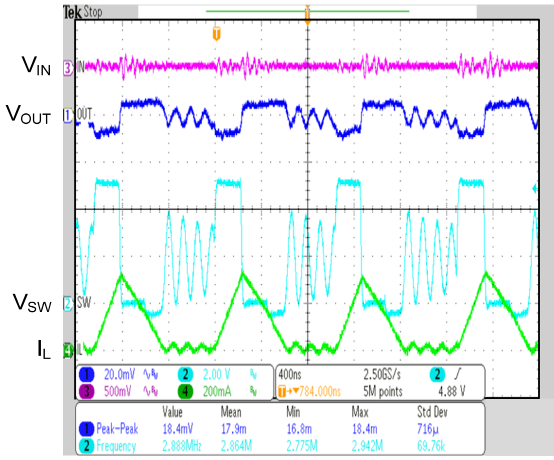


■ TYPICAL CHARACTERISTICS (Cont.)

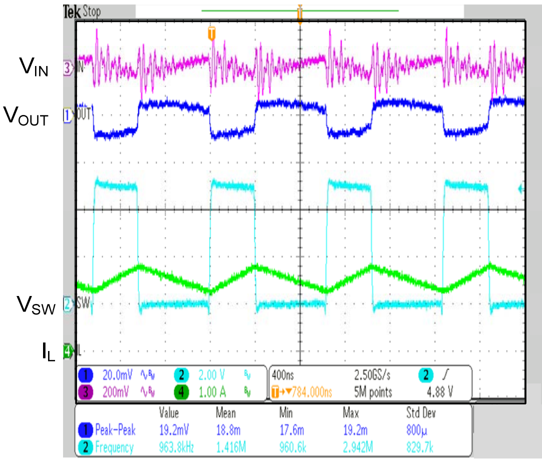
Steady State Operation
(V_{IN}=5V, V_{OUT}=1.8V, I_{OUT}=0A)



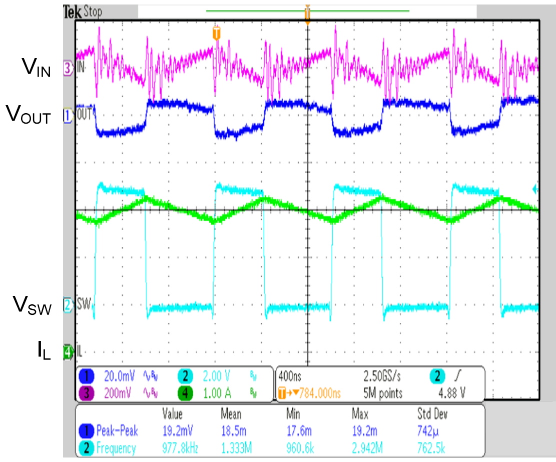
Steady State Operation
(V_{IN}=5V, V_{OUT}=1.8V, I_{OUT}=0.1A)



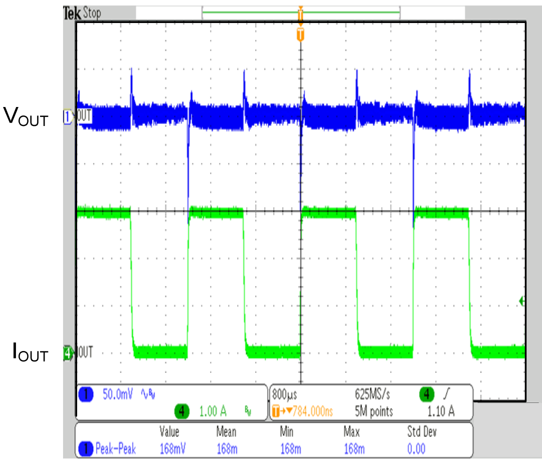
Steady State Operation
(V_{IN}=5V, V_{OUT}=1.8V, I_{OUT}=1.5A)



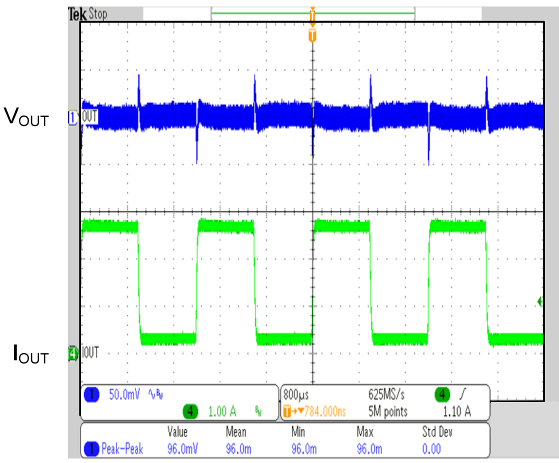
Steady State Operation
(V_{IN}=5V, V_{OUT}=1.8V, I_{OUT}=3A)



Load Transient
(V_{IN}=5V, V_{OUT}=1.8V, I_{OUT}=0~3A)

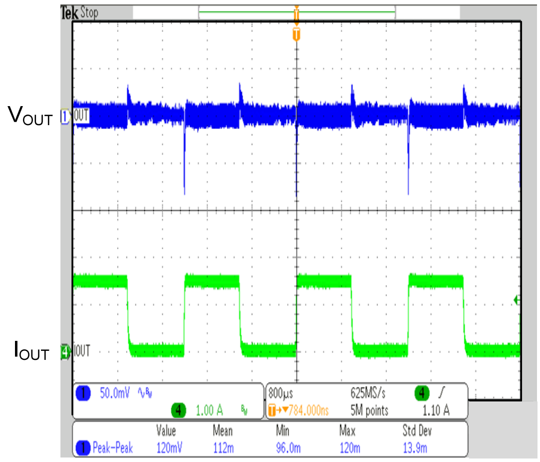


Load Transient
(V_{IN}=5V, V_{OUT}=1.8V, I_{OUT}=0.3A~2.7A)

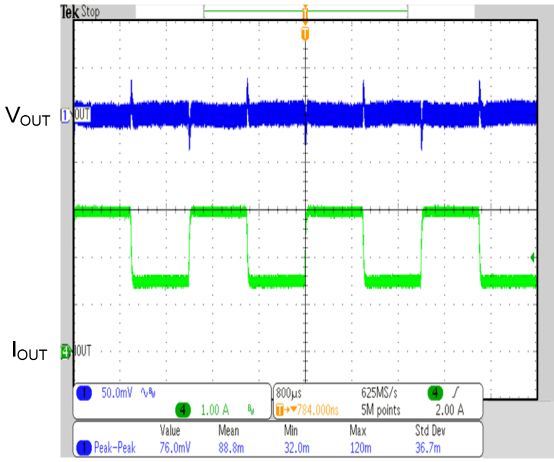


■ TYPICAL CHARACTERISTICS (Cont.)

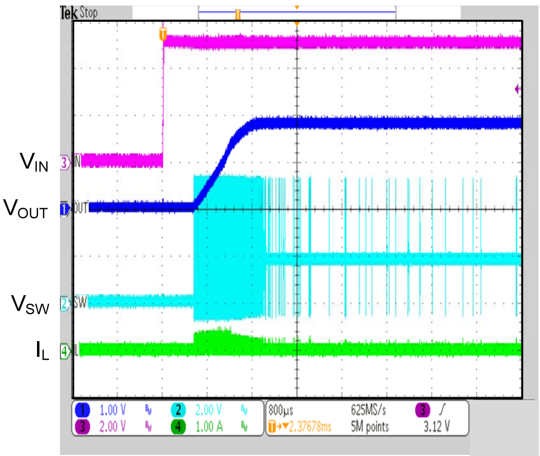
Load Transient
(V_{IN}=5V, V_{OUT}=1.8V, I_{OUT}=0~1.5A)



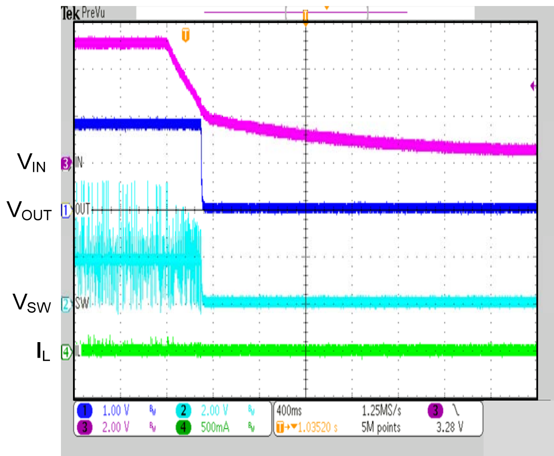
Load Transient
(V_{IN}=5V, V_{OUT}=1.8V, I_{OUT}=1.5~3A)



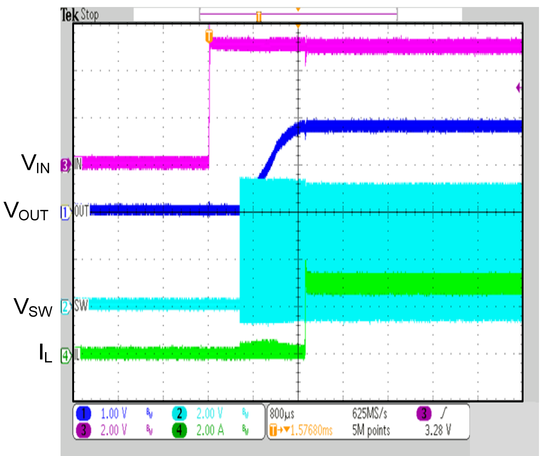
Input Power On
(V_{IN}=5V, V_{OUT}=1.8V, I_{OUT}=0A)



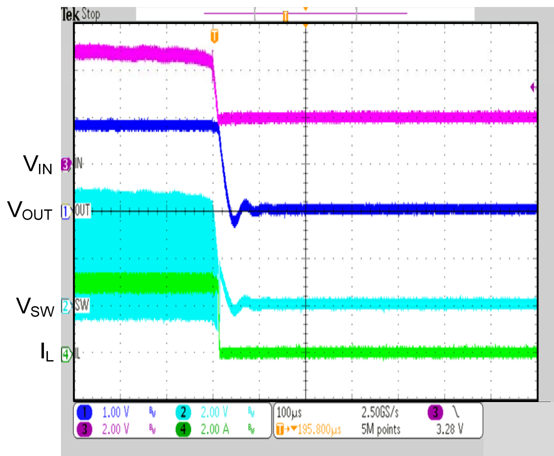
Input Power Off
(V_{IN}=5V, V_{OUT}=1.8V, I_{OUT}=0A)



Input Power On
(V_{IN}=5V, V_{OUT}=1.8V, I_{OUT}=3A)

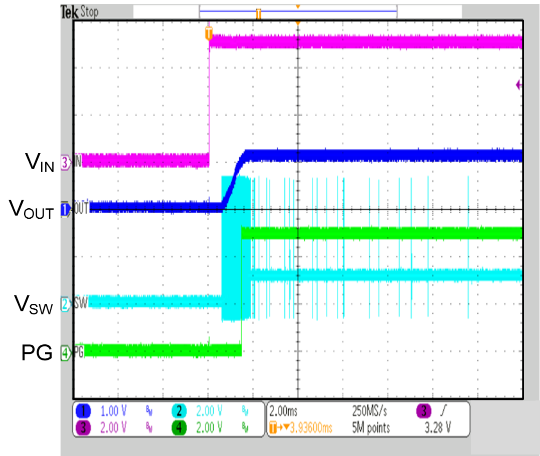


Input Power Off
(V_{IN}=5V, V_{OUT}=1.8V, I_{OUT}=3A)

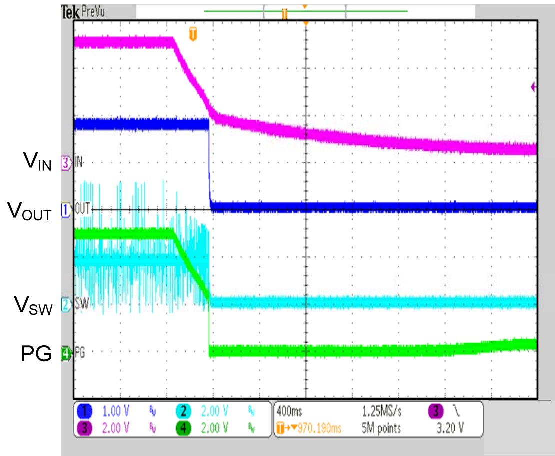


■ TYPICAL CHARACTERISTICS (Cont.)

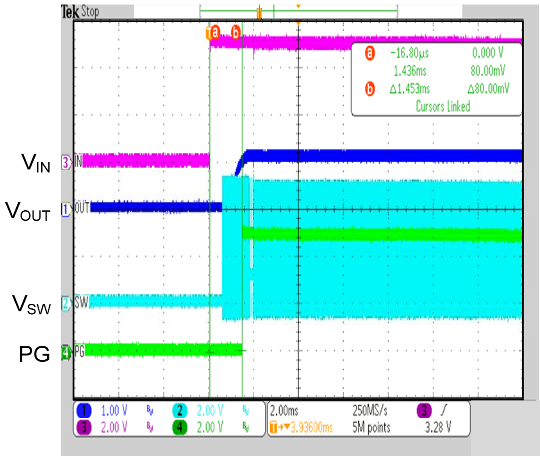
PG when Input Power On
(V_{IN}=5V, V_{OUT}=1.8V, I_{OUT}=0A)



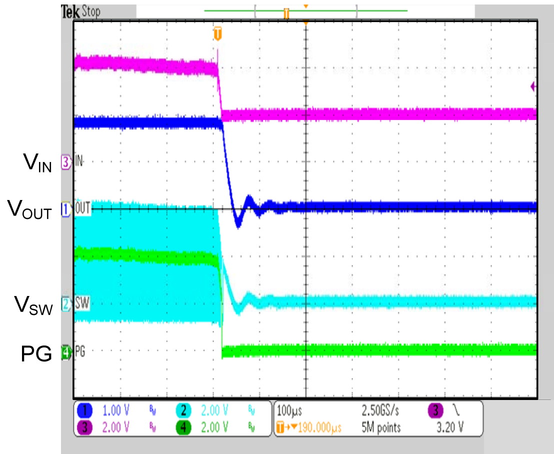
PG when Input Power Off
(V_{IN}=5V, V_{OUT}=1.8V, I_{OUT}=0A)



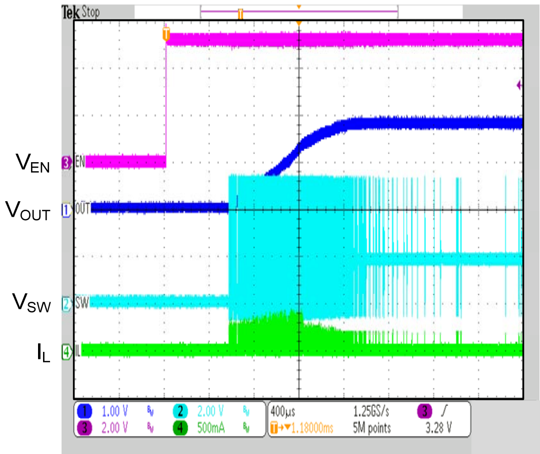
PG when Input Power On
(V_{IN}=5V, V_{OUT}=1.8V, I_{OUT}=3A)



PG when Input Power Off
(V_{IN}=5V, V_{OUT}=1.8V, I_{OUT}=3A)



EN Power On
(V_{IN}=5V, V_{OUT}=1.8V, I_{OUT}=0A)



EN Power Off
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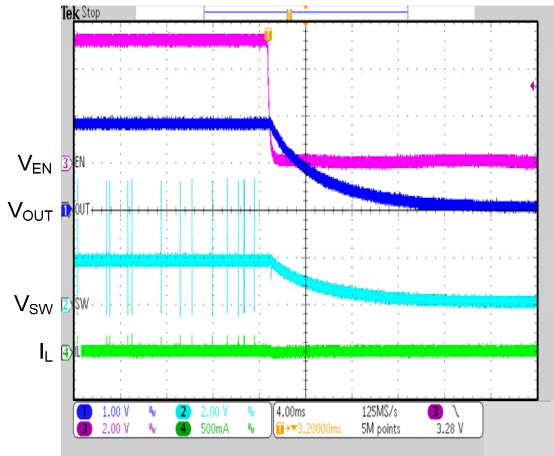
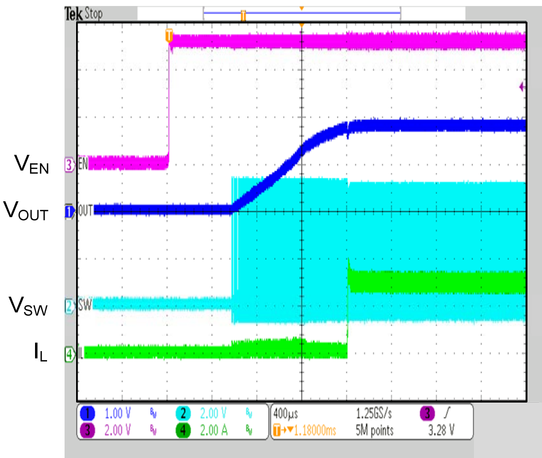
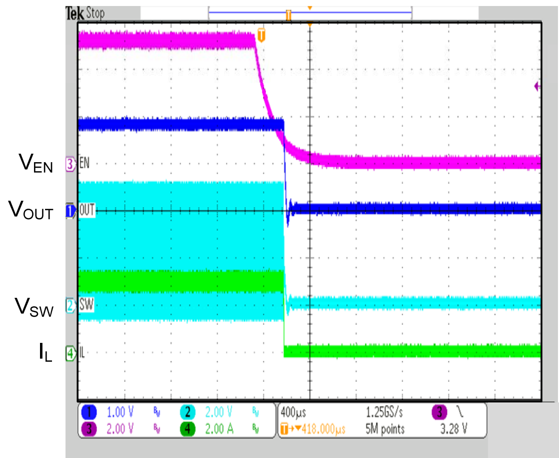


■ TYPICAL CHARACTERISTICS (Cont.)

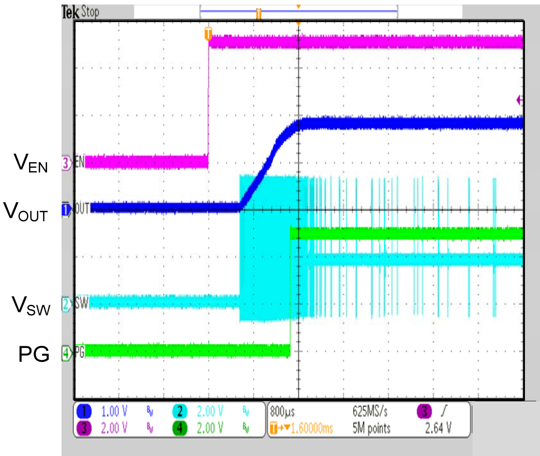
EN Power On
(V_{IN}=5V, V_{OUT}=1.8V, I_{OUT}=3A)



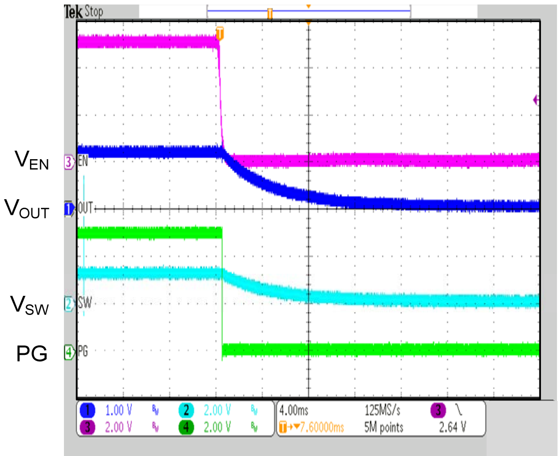
EN Power Off
(V_{IN}=5V, V_{OUT}=1.8V, I_{OUT}=3A)



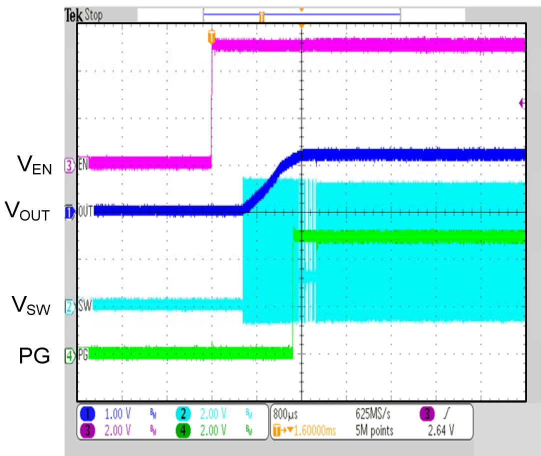
PG when EN Power On
(V_{IN}=5V, V_{OUT}=1.8V, I_{OUT}=0A)



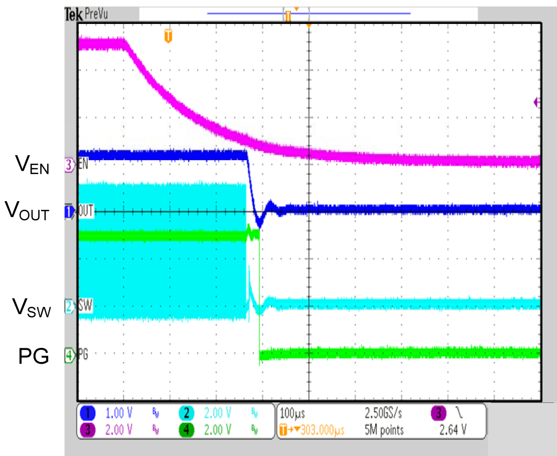
PG when EN Power Off
(V_{IN}=5V, V_{OUT}=1.8V, I_{OUT}=0A)



PG when EN Power On
(V_{IN}=5V, V_{OUT}=1.8V, I_{OUT}=3A)

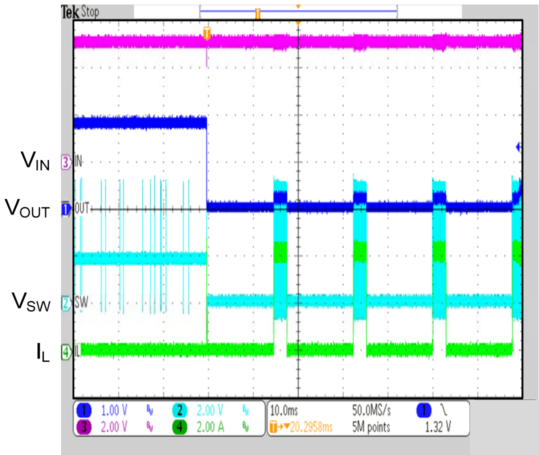


PG when EN Power Off
(V_{IN}=5V, V_{OUT}=1.8V, I_{OUT}=3A)

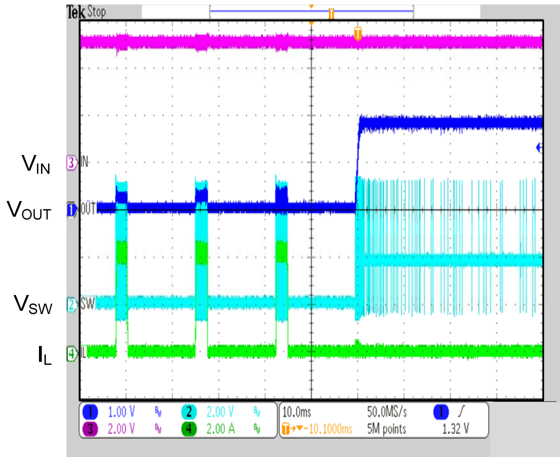


■ TYPICAL CHARACTERISTICS (Cont.)

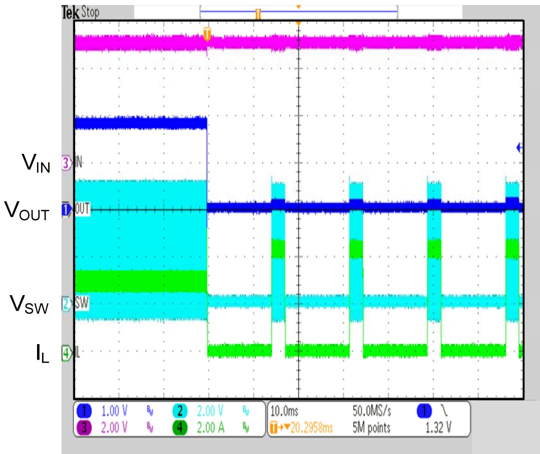
Output Short Entry
(V_{IN}=5V, V_{OUT}=1.8V, I_{OUT}=0A)



Output Short Recovery
(V_{IN}=5V, V_{OUT}=1.8V, I_{OUT}=0A)



Output Short Entry
(V_{IN}=5V, V_{OUT}=1.8V, I_{OUT}=3A)



Output Short Recovery
(V_{IN}=5V, V_{OUT}=1.8V, I_{OUT}=3A)